

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: February 13, 1978

Project Title: *Design of Solar Hot Water System, Solar Makeup Water Preheat System and Solar Building Heating System for the Aircraft Corrosion Control Facility Robins AFB*

Project No: *A-2081-001*

Project Director: *Mr. Charles A. Murphy (X: 3656)*

Sponsor: *Robert and Company Associates*

Agreement Period: From 11/14/77 Until 1/31/78

Type Agreement: *Letter of Intent, dtd. 11/18/77 (to assist on Corps of Engineers, Robins AFB, Georgia, Solar System for Aircraft Corrosion Control Facility Project)*

Amount: *\$7,925*

Reports Required: *Final Report*

Sponsor Contact Person (s):

Technical Matters

*John A. Hartley
Executive Vice President
Robert and Company Associates
96 Poplar Street
Atlanta, Ga. 30303
(404) 525-8411*

Contractual Matters
(thru OCA)

Defense Priority Rating: *None*

Assigned to: ASL/SEMTD (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director-EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
Reports Coordinator (OCA)

Library, Technical Reports Section
EES Information Office
EES Reports & Procedures
Project File (OCA) ✓
Project Code (GTRI)
Other

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT TERMINATION

Date: April 10, 1979

Project Title: Robins AFB Solar Hot Water System -- Phase II

Project No: A-2081-001

Project Director: Mr. J. M. Akridge

Sponsor: Robert and Company Associates; Atlanta, GA 30303

Effective Termination Date: February 16, 1979

Clearance of Accounting Charges: February 16, 1979

Grant/Contract Closeout Actions Remaining:

TERMINATED

- ☒ Final Invoice ~~and Closing Documents~~
- ☐ Final Fiscal Report
- ☐ Final Report of Inventions
- ☐ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other _____

Assigned to: ASL/ECSD (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director--EES
Accounting Office
Procurement Office
Security Coordinator (OCA) ✓
Reports Coordinator (OCA)

Library, Technical Reports Section
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other _____

SIZING OF SOLAR COLLECTOR SYSTEM
FOR ROBIN AFB HOT WATER SYSTEM

60 Percent Submittal

Submitted To

Robert and Company Associate
Atlanta, Georgia

By the

Engineering Experiment Station
Georgia Institute of Technology
225 North Avenue, N. W.
Atlanta, Georgia 30332

February 9, 1979

Project Director

James M. Akridge
Senior Research Engineer
(404) 894-3656

SIZING OF SOLAR COLLECTOR SYSTEM FOR ROBINS AFB HOT WATER SYSTEM

Collector Performance and Availability

The KTA 4-85 non-tracking concentrating collector used in the conceptual design performance study is no longer available. KTA had reliability problems with the KTA 4-85 model and replaced it with the KTA 5-85, which is also a non-tracking concentrating collector. The latest data from independent laboratory tests of the KTA 5-85 indicates a significant reduction in performance. It appears from meetings with KTA personnel that although they have identified and corrected several problems which contributed to the lower performance of the KTA 5-85, it is unlikely that its performance will match the published performance of the KTA 4-85.

Performance of the Robins Solar Hot Water System was recalculated for a large number of other collectors to determine which would come closest to the performance of the KTA 4-85 used in the conceptual design. It was found that the Lennox LSC 18-1S and a new KTA flat plate collector would equal or exceed the performance of the KTA 4-85. Table I shows the average energy collected per month for 16817 ft² (effective) of the new KTA flat plate. Table I shows that the system will supply more than 100 percent of the monthly demand for all months except December. The system will supply 98.2% of the December demand. The Lennox collector will perform very slightly better.

Although the average storage temperatures differ substantially from those calculated in the conceptual design study, the energy collected is substantially the same. Figures 1 - 4 show how this temperature varies throughout the week for average weeks in March, June, September, and December.

TABLE I

SOLAR COLLECTOR SYSTEM SUMMARY

SYSTEM	Solar Hot Water System
COLLECTOR AREA	16817
STORAGE VOLUME	125000
COLLECTOR FLOW RATE	580 GPM (Water-ethylene Glycol)
STORAGE FLOW RATE	1060 GPM
AREA HEAT EXCHANGER	1019 Ft ²
LOCAL LATITUDE	32.67° N
COLLECTION TILT	49°

PERFORMANCE

MONTH	AVERAGE ENERGY COLLECTED/MONTH Btu/month	PERCENT OF SYSTEM DEMAND
January	339.6 x 10 ⁶	100
February	306.7 x 10 ⁶	100
March	339.6 x 10 ⁶	100
April	328.6 x 10 ⁶	100
May	339.6 x 10 ⁶	100
June	328.6 x 10 ⁶	100
July	339.6 x 10 ⁶	100
August	339.6 x 10 ⁶	100
Sept	328.6 x 10 ⁶	100
Oct	329.6 x 10 ⁶	100
Nov	328.6 x 10 ⁶	100
Dec	333.4 x 10 ⁶	98.2

ENERGY COLLECTED PER YEAR	399 x 10 ⁹ Btu
PERCENT OF YEARLY DEMAND	99.8
ENERGY COLLECTED PER FT ² OF COLLECTOR	237.4 x 10 ³ Btu/Ft ² /Yr
COLLECTOR USED FOR EVALUATION	KTA Flat-Plate
COLLECTOR PERFORMANCE EQUATION	N=.87 - .898P *

$$p = \frac{T_{in} - T_{amb}}{I}$$

*Based on effective collector area and ASHRAE pre-stagnation test at Lockheed Research Laboratories, Palo Alto, California.

PERFORMANCE USING KTA FLAT PLATE COLLECTOR

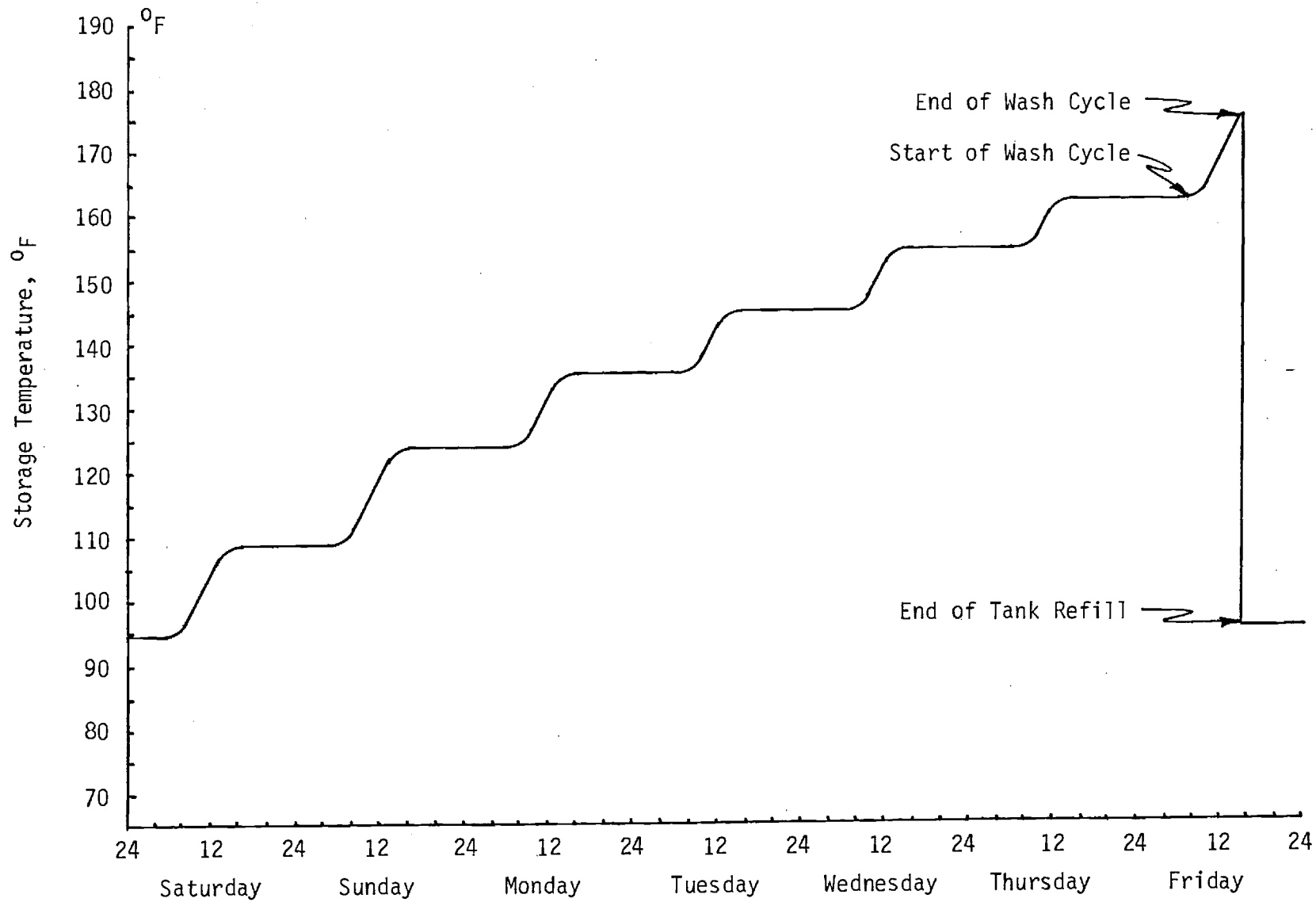


Figure 1. Solar Hot Water Storage Temperature - Average Week in March

PERFORMANCE USING KTA FLAT PLATE COLLECTOR

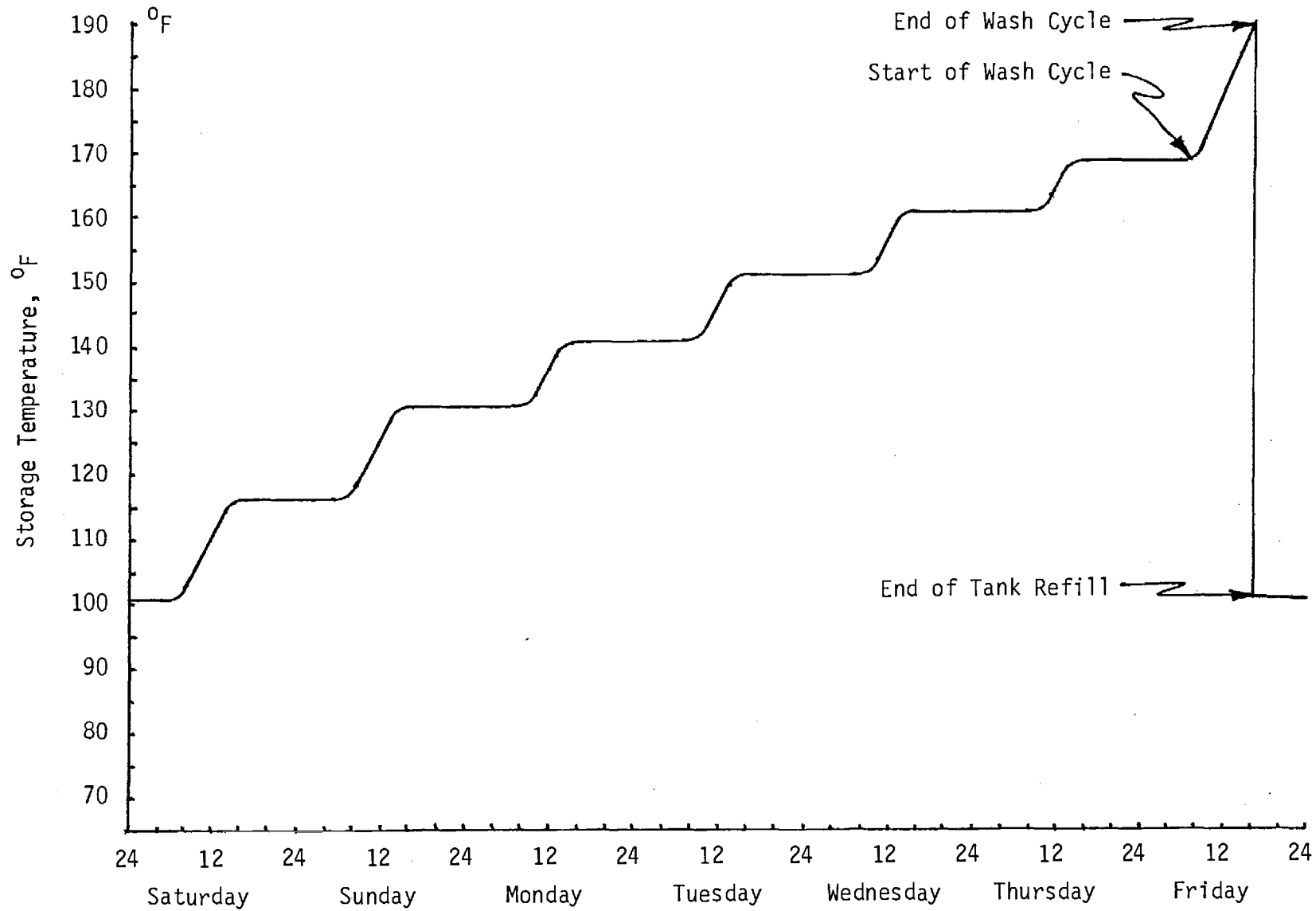


Figure 2. Solar Hot Water Storage Temperature - Average Week in June

PERFORMANCE USING KTA FLAT PLATE COLLECTOR

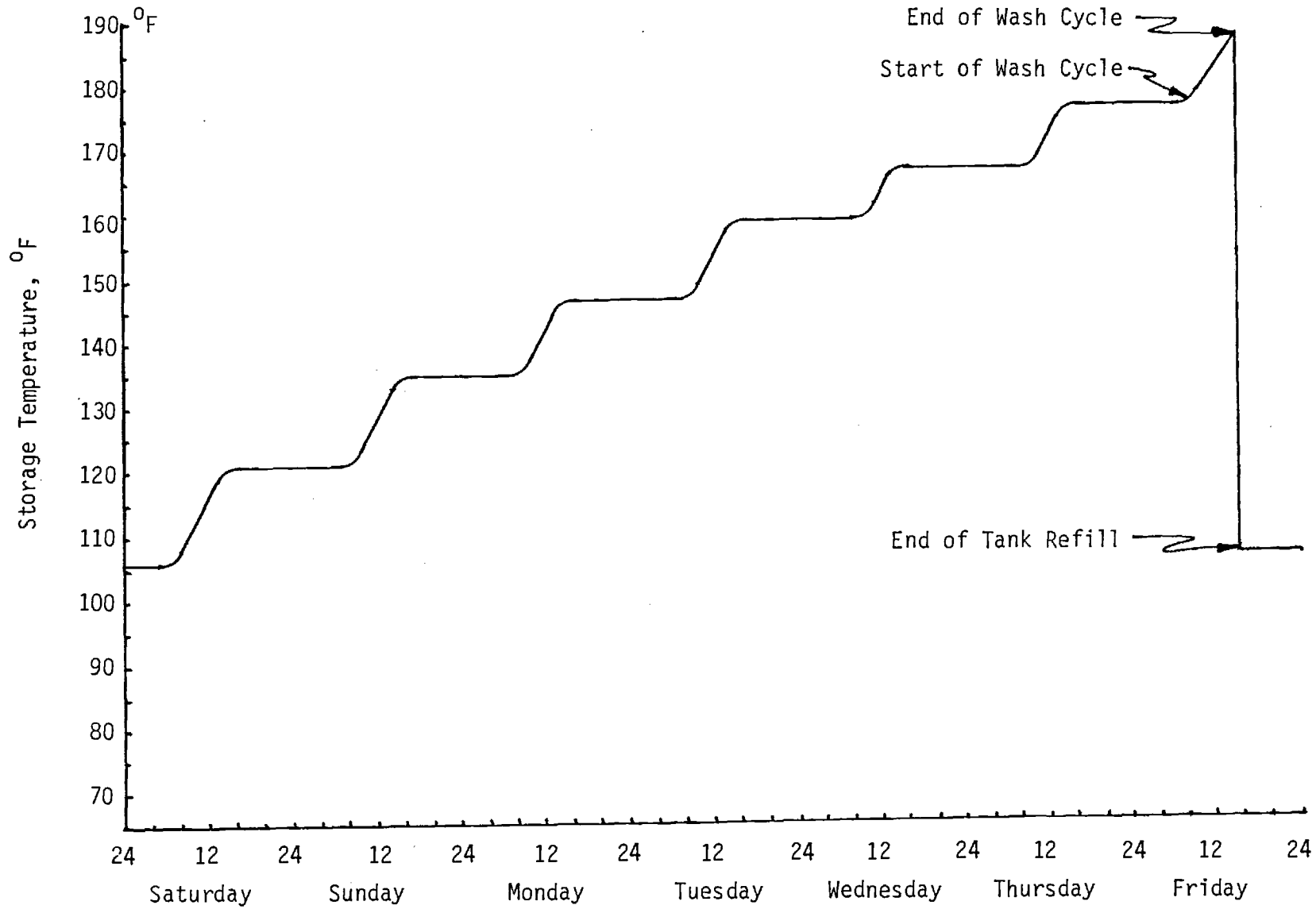


Figure 3. Solar Hot Water Storage Temperature - Average Week in September

PERFORMANCE USING KTA FLAT PLATE COLLECTOR

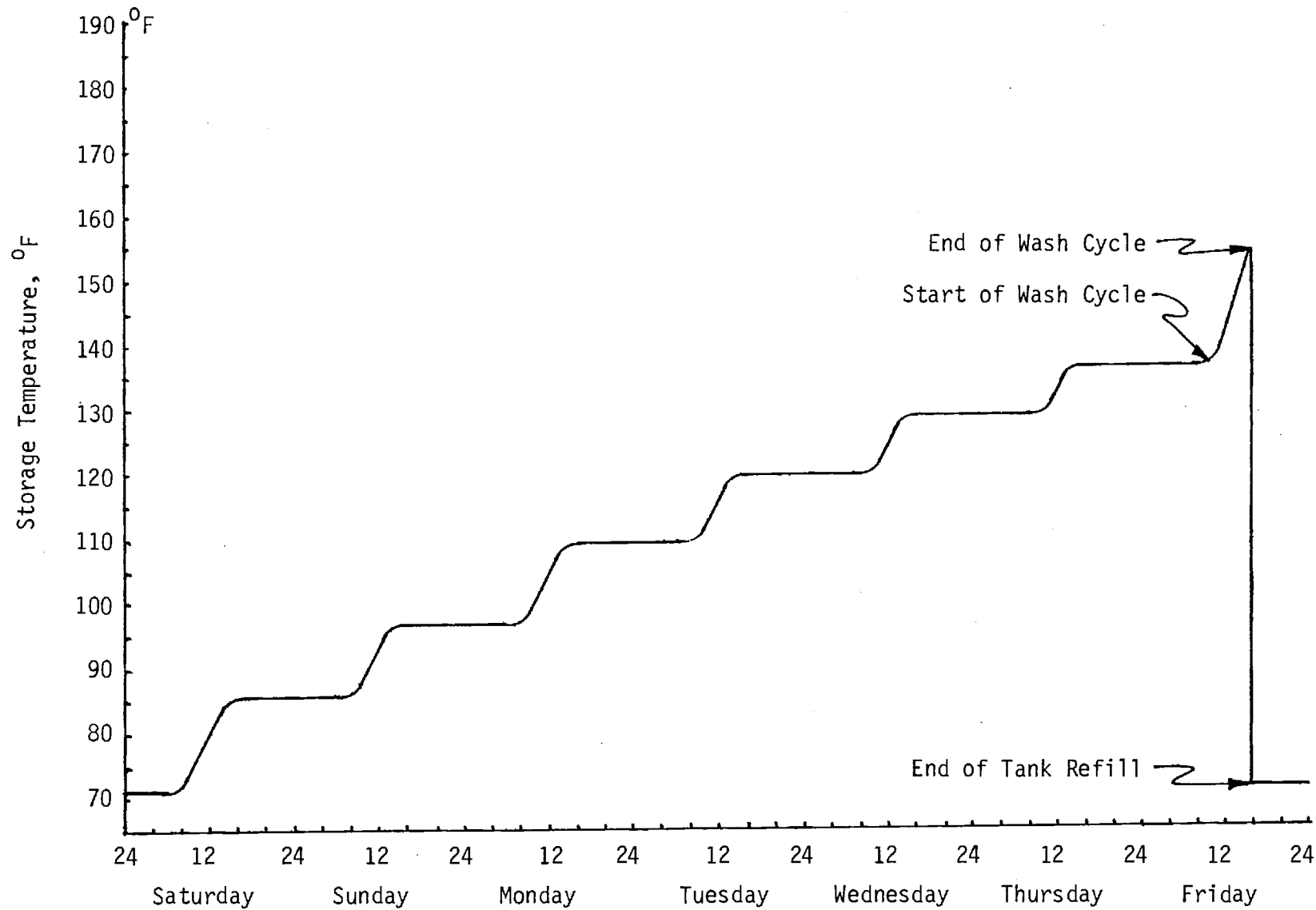


Figure 4. Solar Hot Water Storage Temperature - Average Week in December

Limitations on Solar Hot Water System Analysis

The analysis used average degree day data and synthesized average insolation data in lieu of measured insolation data, hourly "typical year" temperatures and insolation for Robins AFB. This approach "smoothed" results. A quick visual scan of single year weather tapes for Griffin indicates that very cloudy periods exceeding four days may occur several times during a year. Obviously, the system will not provide 100 percent of the Solar Hot Water System requirements for those weeks with three or four overcast days. It also could supply well over 100 percent of the system needs for those weeks with mostly clear days.

Potential System Performance Improvements

Examination of the data from the Solar Hot Water System reveals that despite the collectors being tilted to 49 degrees, the system can collect more energy than can be used during the summer months. System temperature was allowed to float to levels approaching 180⁰ F during the months with excess energy. This reduces the collector efficiency resulting in a decrease in energy collected until it equals energy requirements.

A better approach would be to use this increased collection capability to provide make-up water preheat. It appears that a substantial fraction of the make-up water energy requirements could be met during the excess energy months. The percentage could be further increased by optimizing collector tilt and storage volume for a combined system. The combined system should cost very little more than the Solar Hot Water System alone and would collect substantially more useful energy.

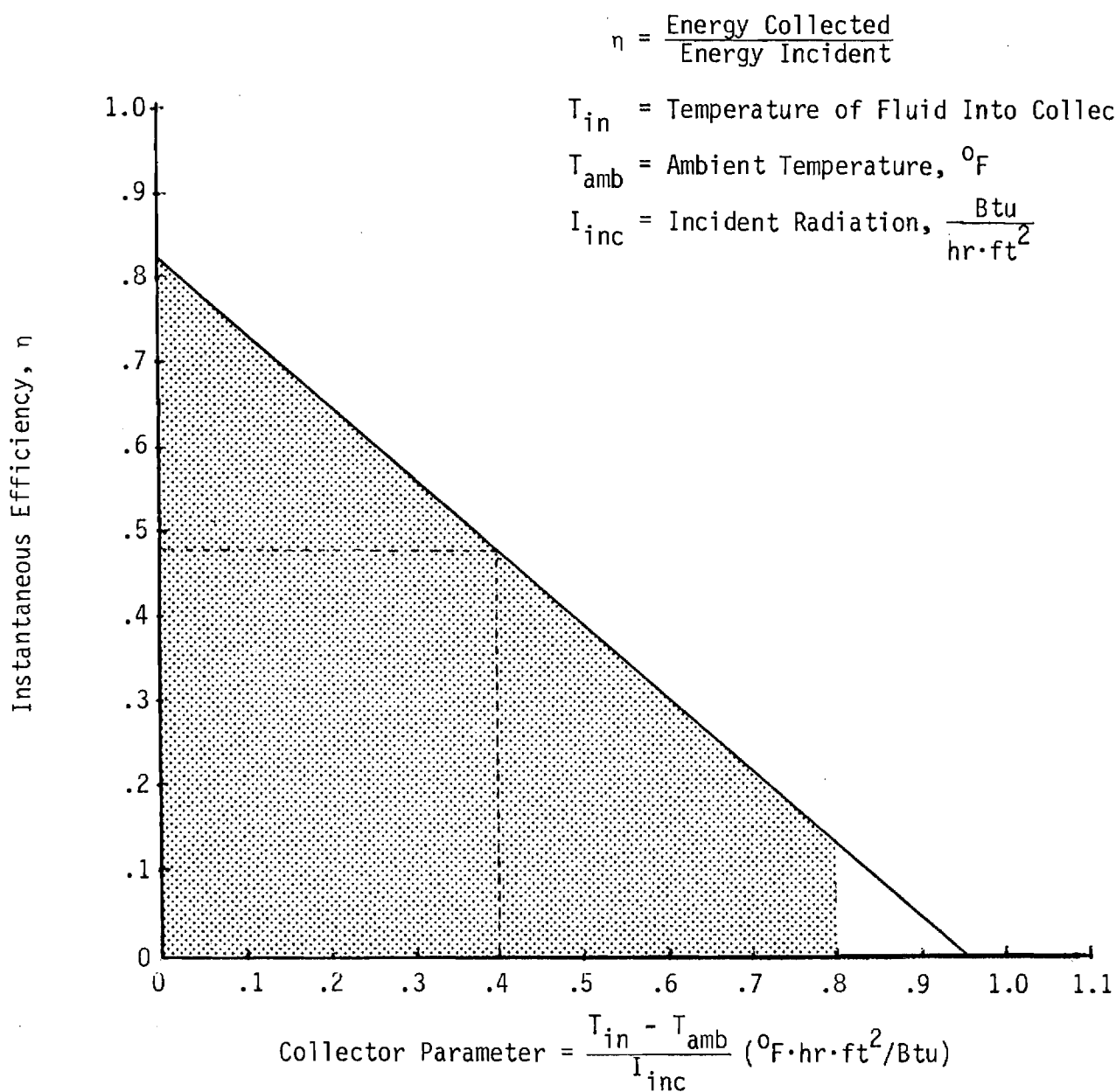


Figure 5. Collector Performance - Based on Effective Area

Performance Specification

A detailed analysis was conducted to determine whether there was a simple parameter which would reliably predict the performance of a collector when used in the Robins Solar Heating System. The most reliable parameter proved to be the area under the efficiency curve out to $P = .8$ (Figure 5,) where;

$$P = \frac{T_{in} - T_{amb}}{I_{inc}} \left(\frac{^{\circ}\text{F} \cdot \text{hr} \cdot \text{Ft}^2}{\text{Btu}} \right)$$

T_{in} = Collector fluid inlet temperature, $^{\circ}\text{F}$

T_{amb} = Ambient Temperature, $^{\circ}\text{F}$

I_{inc} = Incident solar radiation, $\frac{\text{Btu}}{\text{hr} \cdot \text{Ft}^2}$

It was found that energy delivered by the Solar Water Heating System was directly proportional to this area. It was also found that the efficiency at $P = .4$ was a very good measure of the area under the curve out to $P = .8$. Since specifying the efficiency at $P = .4$ is much simpler and easier for others to understand, it is recommended that the collector efficiency (based on effective collector area) at $P = .4$ be used to set a lower limit of performance.

Table II shows the energy collected in December and January collectors with three different efficiencies at $P = .4$. Obviously, the collector with an efficiency of .511 at $P = .4$ will result in the best system performance. It may also result in few bids or bids which are excessively costly. The collector with an efficiency of .48 at $P = .4$ will equal the performance of the higher efficiency collector for all months except December and will provide 96 percent of the December needs compared with 98 percent for the more efficient collector. The collector with an efficiency of .45 at $P = .4$ will meet all of the energy

TABLE II
ENERGY COLLECTION CAPABILITIES OF COLLECTORS
WITH DIFFERENT EFFICIENCIES WHEN USED IN
THE ROBIN HOT WATER SYSTEM

Efficiency At $P = 0.4^{(1)}$	Energy Collected ⁽²⁾			
	December		January	
	Btu/Mo.	% of Load	Btu/Mo.	% of Load
0.511	333.4×10^6	98.2	339.6×10^6	100
0.48	325.9×10^6	96.0	339.6×10^6	100
0.45	317.1×10^6	93.4	331.7×10^6	97.7

$$(1) P = \frac{T_{in} - T_{amb}}{I_{inc}} \left(\frac{^{\circ}\text{F} \cdot \text{hr} \cdot \text{Ft}^2}{\text{Btu}} \right)$$

T_{in} = Temperature of fluid into collector, $^{\circ}\text{F}$

T_{amb} = Ambient Temperature, $^{\circ}\text{F}$

I_{inc} = Incident Radiation, $\text{Btu/hr} \cdot \text{Ft}^2$

(2) Based on $16,817 \text{ ft}^2$ of effective collector area tilted 49° from horizontal.

needs for all months except December and January. It will provide 93.4 percent of the December demand and 97.7 percent of the January demand.

It is recommended that the specification require that the collector be tested according to ASHRAE 93-77, "Method of Testing for Rating Solar Collectors Based on Thermal Performance," with the exception that efficiency shall be determined and reported using effective collector area (aperture) rather than gross collector area. Testing must be done by an independent test laboratory and the results certified. The manufacturer must certify that the collector is a production model and not one specially prepared for certification. It is recommended that the specification require that the collector efficiency following the stagnation test specified in ASHRAE 93-77 be equal to or greater than .48 at $P = .4$, where;

$$P = \frac{T_{in} - T_{amb}}{I_{inc}} \left(\frac{^{\circ}\text{F} \cdot \text{hr} \cdot \text{Ft}^2}{\text{Btu}} \right)$$

T_{in} = Collector fluid inlet temperature, $^{\circ}\text{F}$

T_{amb} = Ambient temperature, $^{\circ}\text{F}$

I_{inc} = Incident solar radiation, $\frac{\text{Btu}}{\text{hr} \cdot \text{Ft}^2}$

It is recommended that the collector have all copper fluid passages and that the collector be designed to prevent moisture condensation or accumulation within the collector box or between the glazings if more than one is used. It is recommended that the manufacturer supply data on the absorber coating which will permit estimation of any possible change in collector performance with time. If glazings other than glass are used, the manufacturer must supply data which will permit determination of performance due to degradation of the glazing with time.